

EXAMPLE 13

Tests were conducted to compare the hydrolytic stability of certain representative formulations set forth in Table 11 with commercially available hydraulic fluids to demonstrate the superior hydrolytic stability of the fluid compositions of the instant invention containing either or both the additive package suitable for use in fluid compositions of the instant invention and the isoalkyl phosphate ester-based base stocks and the isoalkyl phosphate ester/aryl phosphate ester-based base stocks. In each of the tests, a 301 stainless steel tube having dimensions of approximately 1.90 cm (0.75 in) I.D.×22.86 cm (9.0 in) length and a capacity of approximately 53 cc was filled to approximately 85% capacity (approximately 45 cc) with the fluid to be tested. The head space in the tube was filled with air. The tube was capped and heated to a predetermined test temperature—325° F. (162.7° C.)—and maintained at that temperature throughout the test. Each tube was monitored over time and samples were taken to follow trends in the fluid's chemical composition, in particular the concentration of the acid scavenger (epoxide) present in the sample. When the epoxide is 100% depleted, the fluid is typically degraded to the point that its usefulness as an aircraft hydraulic fluid has essentially been exhausted. An epoxide depletion approached 100%, test samples were titrated for acidity. When the neutralization number of the fluid reached 1.5 or greater, the test was halted and the number of hours recorded. The parameters and results are tabulated in Table 12.

TABLE 12

Fluid Hydrolytic Stability @ 325° F.		
Fluid (from Table 11)	Stability, hr. @ % Water	
	<0.2 (Neat)	0.5
Skydrol @ LD-4 ¹	300	37
Hyjet @ IVA ²	200	28
2	450	85
5	1000	310
11	>1000	350

¹Commercially available from Monsanto Company.

²Commercially available from Chevron International Oil Company.

What is claimed is:

1. A fluid composition suitable for use as an aircraft hydraulic fluid, comprising:

- (a) a fire resistant phosphate ester base stock, the base stock comprising between about 50% and about 85% by weight of a trialkyl phosphate in which the alkyl substituents are substantially isoalkyl C₄ or C₅ and are bonded to the phosphate moiety via a primary carbon atom, between about 18% and about 35% by weight of a dialkyl aryl phosphate in which the alkyl substituents are as previously defined, and between about 0% and about 5% by weight of an alkyl diaryl phosphate in which the alkyl substituent is as previously defined, with the proviso that the sum of the proportionate amount of each base stock component must equal 100%;
- (b) an acid scavenger in an amount effective to neutralize phosphoric acid and phosphoric acid partial esters formed in situ by hydrolysis of any of the phosphate esters of said base stock;
- (c) an anti-erosion additive in an amount effective to inhibit flow-induced electrochemical or zeta corrosion of the flow-metering edges of hydraulic servo valves in hydraulic systems;

(d) a viscosity index improver in an amount effective to cause the fluid composition to exhibit a viscosity of at least about 3.0 centistokes at about 210° F., at least about 9.0 centistokes at about 100° F., and less than about 4200 centistokes at -65° F.; and

(e) an antioxidant in an amount effective to inhibit oxidation of fluid composition components in the presence of oxidizing agents.

2. A fluid composition as set forth in claim 1 wherein said dialkyl aryl phosphate is a dialkyl phenyl phosphate.

3. A fluid composition as set forth in claim 1 wherein the viscosity index improver is present in an amount effective to cause the fluid composition to exhibit a viscosity between about 3 and about 5 centistokes at about 210° F. and between about 9 and about 15 centistokes at 100° F.

4. A fluid composition as set forth in claim 1 containing a viscosity index improver in a proportion of between about 3% and about 10% by weight of the fluid composition.

5. A fluid composition as set forth in claim 1 containing a 2,4,6-trialkylphenol in a proportion of between about 0.1% and about 1.0% by weight of the fluid composition, a di(alkylphenyl)amine in a proportion of between about 0.3% and about 1.0% by weight of the fluid composition, and a hindered polyphenol selected from the group consisting of bis(3,5-dialkyl-4-hydroxyaryl)methane and 1,3,5-trialkyl-2,4,6-tris(3,5-di-tert-butyl-4-hydroxyaryl)benzene and mixtures thereof, in a proportion of between about 0.3% and about 1.0% by weight of the fluid composition.

6. A fluid composition as set forth in claim 2 wherein phosphate esters containing an aryl substituent do not constitute more than about 25% by weight of the base stock.

7. A fluid composition suitable for use as an aircraft hydraulic fluid, comprising:

- (a) a fire resistant phosphate ester base stock comprising between about 10% and about 90% of a trialkyl phosphate wherein the alkyl substituents are substantially isoalkyl C₄ and C₅ and are bonded to the phosphate moiety via a primary carbon atom, between about 0% and about 70% by weight of a dialkyl aryl phosphate wherein the alkyl substituents are as previously defined, and between about 0% and about 25% by weight of an alkyl diaryl phosphate wherein the alkyl substituent is as previously defined, with the proviso that the sum of the proportionate amount of each base stock component must equal 100%;
- (b) a viscosity index improver in a proportion of between about 3% and about 10% by weight of the fluid composition, the viscosity index improver comprising a methacrylate ester polymer, the repeating units of which substantially comprise butyl and hexyl methacrylate, at least 95% by weight of the polymer having a molecular weight of between about 50,000 and about 1,500,000;
- (c) an anti-erosion agent in a proportion of between about 0.02% and about 0.08% by weight of the fluid composition, the anti-erosion agent comprising an alkali metal salt of a perfluoroalkyl sulfonic acid, the alkyl substituent of which is selected from the group consisting of hexyl, heptyl, octyl, nonyl, decyl, and mixtures thereof;
- (d) an acid scavenger in a proportion of between about 1.5% and about 10% by weight of the fluid composition, the acid scavenger comprising an epoxide compound;
- (e) a 2,4,6-trialkylphenol in a proportion of between about 0.1% and about 1.0% by weight of the fluid composition.

tion;

(f) a di(alkylphenyl)amine in a proportion of between about 0.3% and about 1.0% by weight of the fluid composition; and

(g) a hindered polyphenol selected from the group consisting of bis(3,5-dialkyl-4-hydroxyaryl)methane, 1,3,5-trimethyl-2,4,6-tris(3,5-di-tert-butyl-4-hydroxyaryl)benzene and mixtures thereof in a proportion of between about 0.3% and about 1.0% by weight of the fluid composition.

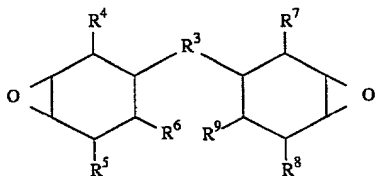
8. A fluid composition suitable for use as an aircraft hydraulic fluid, comprising:

(a) a fire resistant phosphate ester base stock comprising between about 10% and about 90% by weight of a trialkyl phosphate wherein the alkyl substituents are substantially isoalkyl C₄ or C₅ and are bonded to the phosphate moiety via a primary carbon atom, between about 0% and about 70% by weight of a dialkyl aryl phosphate wherein the alkyl substituents are as previously defined, and between about 0% and about 25% by weight of an alkyl diaryl phosphate wherein the alkyl substituent is as previously defined, with the proviso that the sum of the proportionate amount of each base stock component must equal 100%;

(b) a viscosity index improver in a proportion of between about 3% and about 10% by weight of the fluid composition, the viscosity index improver comprising a methacrylate ester polymer, the repeating units of which substantially comprise butyl and hexyl methacrylate, at least 95% by weight of the polymer having a molecular weight of between about 50,000 and about 1,500,000;

(c) an anti-erosion agent in a proportion of between about 0.02% and about 0.08% by weight of the fluid composition, the anti-erosion agent comprising an alkali metal salt of a perfluoroalkylsulfonic acid, the alkyl substituent of which is selected from the group consisting of hexyl, heptyl, octyl, nonyl, decyl, and mixtures thereof;

(d) an acid scavenger in a proportion of between about 1.5% and about 10% by weight of the composition, the acid scavenger selected from the group consisting of a derivative of a 3,4-epoxy cyclohexane carboxylate and a diepoxide compound corresponding to the formula



wherein R³ is an organic group containing 1 to 10 carbon atoms, from 0 to 6 oxygen atoms and from 0 to 6 nitrogen atoms, and R⁴ through R⁹ are independently selected from among hydrogen and aliphatic groups containing 1 to 5 carbon atoms, and mixtures of the 3,4-epoxycyclohexane carboxylate and the diepoxide compound;

(e) 2,4,6-trialkylphenol in a proportion of between about 0.1% and about 1.0% by weight of the composition;

(f) a di(alkylphenyl)amine in a proportion of between about 0.3% and about 1.0% by weight of the fluid composition; and

(g) a hindered polyphenol selected from the group con-

sisting of bis(3,5-dialkyl-4-hydroxyaryl)methane, 1,3,5-trimethyl-2,4,6-tris(3,5-di-tert-butyl-4-hydroxyaryl)benzene, and mixtures thereof in a proportion of between about 0.3% and about 1.0% by weight of the fluid composition.

9. A fluid composition as set forth in claim 8 further comprising benzotriazole or a benzotriazole derivative in a proportion of between about 0.005% and about 0.09% as a copper corrosion inhibitor.

10. A fluid composition as set forth in claim 8 further comprising between about 0.0035% and about 0.010% by weight of an alkali metal arene.

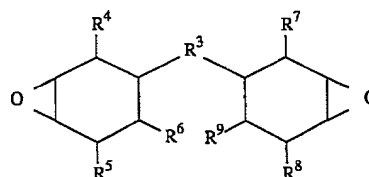
11. A fluid composition suitable for use as an aircraft hydraulic fluid, comprising:

(a) a fire resistant phosphate ester base stock comprising between about 35% and about 90% by weight of a trialkyl phosphate wherein the alkyl substituents are substantially isoalkyl C₄ and C₅ and are bonded to the phosphate moiety via a primary carbon atom, between about 0% and about 35% by weight of a dialkyl aryl phosphate wherein the alkyl substituents are as previously defined, and between about 0% and about 20% by weight of a triaryl phosphate, with the proviso that the sum of the proportionate amount of each base stock component must equal 100%;

(b) a viscosity index improver in a proportion of between about 3% and about 10% by weight of the fluid composition, the viscosity index improver comprising a methacrylate ester polymer, the repeating units of which substantially comprise butyl and hexyl methacrylate, at least 95% by weight of the polymer having a molecular weight of between about 50,000 and about 1,500,000;

(c) an anti-erosion agent in a proportion of between about 0.02% and about 0.08% by weight of the fluid composition, the anti-erosion agent comprising an alkali metal salt of a perfluoroalkyl sulfonic acid, the alkyl substituent of which is selected from the group consisting of hexyl, heptyl, octyl, nonyl, decyl, and mixtures thereof;

(d) an acid scavenger in a proportion of between about 1.5% and about 10% by weight of the fluid composition, the acid scavenger selected from the group consisting of a derivative of a 3,4-epoxy cyclohexane carboxylate and a diepoxide compound corresponding to the formula



wherein R³ is an organic group containing 1 to 10 carbon atoms, from 0 to 6 oxygen atoms, and from 0 to 6 nitrogen atoms, and R⁴ through R⁹ are independently selected from among hydrogen and aliphatic groups containing 1 to 5 carbon atoms, and mixtures of the 3,4-epoxycyclohexanecarboxylate and the diepoxide compound;

(e) a 2,4,6-trialkylphenol in a proportion of between about 0.1% and about 1.0% by weight of the fluid composition;

(f) a di(alkylphenyl)amine in a proportion of between about 0.3% and about 1.0% by weight of the fluid

composition; and

- (g) a hindered polyphenol selected from the group consisting of bis(3,5-dialkyl-4-hydroxyaryl) methane, 1,3,5-trimethyl-2,4,6-tris(3,5-di-tert-butyl-4-hydroxyaryl)benzene and mixtures thereof in a proportion of between about 0.3% and about 1.0% by weight of the fluid composition.

12. A fluid composition as set forth in claim 11 wherein the base stock comprises between about 80% and about 90% by weight of the trialkyl phosphate and between about 10% and about 20% by weight of a tri(alkylaryl)phosphate.

13. A fluid composition as set forth in claim 12 wherein the tri(alkylaryl) phosphate is selected from the group consisting of tri(isopropylphenyl)phosphate, tri(isobutylphenyl)phosphate, and tri(tert-butylphenyl)phosphate.

14. A fluid composition as set forth in claim 8 wherein the base stock comprises between about 10% and about 72% by weight of the trialkyl phosphate, between about 18% and about 70% by weight of the dialkyl aryl phosphate, and between about 0% and about 25% by weight of the alkyl diaryl phosphate.

15. A fluid composition as set forth in claim 14 wherein the base stock comprises between about 10% and about 25% by weight of the trialkyl phosphate, between about 45% and about 70% by weight of the dialkyl aryl phosphate, and between about 5% and about 25% by weight of the alkyl diaryl phosphate.

16. A fluid composition as set forth in claim 14 wherein the base stock comprises between about 50% and about 72% by weight of the trialkyl phosphate, between about 18% and about 35% by weight of the dialkyl aryl phosphate, and between about 0% and about 10% by weight of the alkyl diaryl phosphate.

17. A fluid composition as set forth in claim 8 wherein the base stock contains between about 0% and about 5% by weight of the alkyl diaryl phosphate.

18. A composition as set forth in claim 8 wherein said alkyl substituents are substantially isobutyl or isopentyl.

19. A fluid composition suitable for use as an aircraft hydraulic fluid, comprising:

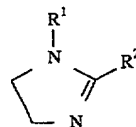
- (a) a fire resistant phosphate ester base stock, the base stock comprising between about 10% and about 90% by weight of a trialkyl phosphate wherein the alkyl substituents are substantially isobutyl or isopentyl and are bonded to the phosphate moiety via a primary carbon atom, between about 0% and about 70% by weight of a dialkyl aryl phosphate wherein the alkyl substituents are as previously defined, and between about 0% and about 25% by weight of an alkyl diaryl phosphate wherein the alkyl substituent is as previously defined, with the proviso that the sum of the proportionate amount of each base stock component must equal 100%;
- (b) an acid scavenger in an amount effective to neutralize phosphoric acid partial esters formed in situ by hydrolysis of any of the phosphate esters of the base stock;
- (c) an anti-erosion additive in an amount effective to inhibit flow-induced electrochemical or zeta corrosion of the flow-metering edges of hydraulic servo valves in hydraulic systems;
- (d) a viscosity index improver in an amount effective to cause the fluid composition to exhibit a viscosity of at least about 3.0 centistokes at about 210° F., at least about 9.0 centistokes at about 100° F., and less than about 4200 centistokes at -65° F.; and

- (e) an antioxidant in an amount effective to inhibit oxidation of fluid composition components in the presence of oxidizing agents.

20. A fluid composition as set forth in claim 19 wherein the trialkyl phosphate is triisobutyl phosphate and the dialkyl aryl phosphate is diisobutyl phenyl phosphate.

21. A fluid composition as set forth in claim 19 further comprising benzotriazole or a benzotriazole derivative in a proportion of between about 0.005% and about 0.09% by weight as a copper corrosion inhibitor.

22. A fluid composition as set forth in claim 19 further comprising a 4,5-dihydroimidazole compound corresponding to the formula



where R¹ is selected from the group consisting of hydrogen, alkyl, alkenyl, hydroxyalkyl, hydroxyalkenyl, alkoxyalkyl and alkoxyalkenyl, and R² is selected from the group consisting of alkyl, alkenyl and aliphatic carboxylate.

23. A fluid composition as set forth in claim 22 wherein the 4,5-dihydroimidazole is selected from the group consisting of 2-(8-heptadecenyl)-4,5-dihydro-1H-imidazole-1-ethanol and the condensation product of a C₁₄ to C₁₈ fatty acid and 4,5-dihydro-1H-imidazole.

24. A fluid composition as set forth in claim 23 wherein the 4,5-dihydroimidazole compound is the condensation product of a C₁₆ to C₁₈ fatty acid and 4,5-dihydro-1H-imidazole.

25. A fluid composition as set forth in claim 22 wherein the antioxidant comprises a hindered phenol.

26. A fluid composition as set forth in claim 25 wherein the hindered phenol comprises a hindered polyphenol compound selected from the group consisting of bis(3,5-dialkyl-4-hydroxyaryl)methane, 1,3,5-trialkyl-2,4,6-tris(3,5-di-tert-butyl-4-hydroxyaryl)benzene, and mixtures thereof.

27. A fluid composition as set forth in claim 25 wherein the antioxidant further comprises an amine compound.

28. A fluid composition as set forth in claim 27 wherein the antioxidant amine compound is a diarylamine.

29. A fluid composition as set forth in claim 28 wherein the diarylamine is di(p-octylphenyl)amine.

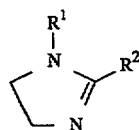
30. A fluid composition as set forth in claim 28 further comprising up to about 0.7% by weight of 2,6-di-tert-butyl-p-cresol.

31. A fluid composition suitable for use as an aircraft hydraulic fluid, comprising:

- (a) a fire resistant phosphate ester base stock, the base stock comprising between about 10% and about 90% by weight of a trialkyl phosphate wherein the alkyl substituents are substantially isoalkyl C₄ or C₅ and are bonded to the phosphate moiety via a primary carbon atom, between about 0% and about 70% by weight of a dialkyl aryl phosphate wherein the alkyl substituents are as previously defined, and between about 0% and about 25% by weight of an alkyl diaryl phosphate wherein the alkyl substituent is as previously defined;
- (b) an acid scavenger in an amount effective to neutralize phosphoric acid and phosphoric acid partial esters formed in situ by hydrolysis of any of the phosphate esters of the base stock;
- (c) an anti-erosion additive in an amount effective to

inhibit flow-induced electrochemical or zeta corrosion of the flow-metering edges of hydraulic servo valves in hydraulic systems;

- (d) a viscosity index improver in an amount effective to cause the fluid composition to exhibit a viscosity of at least about 3.0 centistokes at about 210° F., at least about 9.0 centistokes at about 100° F., and less than about 4200 centistokes at -65° F.;
- (e) an antioxidant in an amount effective to inhibit oxidation of fluid composition components in the presence of oxidizing agents; and
- (f) a 4,5-dihydroimidazole compound in an amount effective to increase the stability of the composition by at least 25% at 300° F. as measured by epoxide depletion, the 4,5-dihydroimidazole compound corresponding to the formula



wherein R¹ is selected from the group consisting of hydrogen, alkyl, alkenyl, hydroxyalkyl, hydroxyalkenyl, alkoxyalkyl and alkoxyalkenyl, and R² is selected from the group consisting of alkyl, alkenyl and aliphatic carboxylate.

32. A fluid composition as set forth in claim 31 wherein R¹ is hydrogen or lower alkyl and R² is a fatty acid residue.

33. A fluid composition as set forth in claim 31 wherein R¹ is hydroxyalkyl and R² is alkenyl.

34. A fluid composition as set forth in claim 31 wherein the 4,5-dihydroimidazole is selected from the group consisting of 2-(8-heptadecenyl)-4,5-dihydro-1H-imidazole-1-ethanol and the condensation product of a C₁₄ to C₁₈ fatty acid and 4,5-dihydro-1H-imidazole.

35. A fluid composition as set forth in claim 34 wherein the 4,5-dihydroimidazole compound is the condensation product of a C₁₆ to C₁₈ fatty acid and 4,5-dihydro-1H-imidazole.

36. A composition as set forth in claim 35 wherein said alkyl substituents of said trialkyl phosphate and said dialkyl aryl phosphate are substantially isobutyl or isopentyl.

37. A fluid composition as set forth in claim 31 wherein the antioxidant comprises a hindered phenol.

38. A fluid composition as set forth in claim 37 wherein the hindered phenol comprises a hindered polyphenol compound selected from the group consisting of bis(3,5-dialkyl-4-hydroxyaryl)methane, 1,3,5-trialkyl-2,4,6-tris(3,5-di-tert-butyl-4-hydroxyaryl)benzene and mixtures thereof.

39. A fluid composition as set forth in claim 37 wherein said antioxidant further comprises an amine compound.

40. A composition as set forth in claim 39 further comprising a diarylamine antioxidant.

41. A composition as set forth in claim 40 wherein said diarylamine comprises di(p-octylphenyl)amine.

42. A composition as set forth in claim 40 further comprising up to about 1.0% by weight of 2,6-di-tertiary-butyl p-cresol.

43. A composition as set forth in claim 31 wherein said alkyl substituents of said trialkyl phosphate and said dialkyl aryl phosphate are substantially isobutyl or isopentyl.

44. A fluid composition as set forth in claim 1 wherein the viscosity index improver is a methacrylate ester polymer, the repeating units of which substantially comprise butyl and hexyl methacrylate, at least 95% by weight of the polymer

having a molecular weight of between about 50,000 and about 1,500,000.

45. A fluid composition as set forth in claim 19 further comprising an anti-foam agent.

46. A fluid composition as set forth in claim 45 wherein the anti-foam agent is a polyalkylsiloxane.

47. A fluid composition as set forth in claim 46 wherein the polyalkylsiloxane is polymethylsiloxane.

48. A fluid composition as set forth in claim 45 wherein the anti-foam agent is present in a concentration of from about 0.0001% to about 0.001% by weight of the fluid composition.

49. A fluid composition as set forth in claim 48 wherein the anti-foam agent is present in a concentration of about 0.0005% by weight of the fluid composition.

50. A fluid composition suitable for use as an aircraft hydraulic fluid, comprising:

- (a) a fire resistant phosphate ester base stock, the base stock comprising between about 10% and about 100% by weight of a trialkyl phosphate in which the alkyl substituents are substantially isoalkyl C₄ or C₅ and are bonded to the phosphate moiety via a primary carbon atom, between about 0% and about 70% by weight of a dialkyl aryl phosphate in which the alkyl substituents are as previously defined, and between about 0% and about 25% by weight of an alkyl diaryl phosphate in which the alkyl substituent is as previously defined, with the proviso that the sum of the proportionate amount of each base stock component must equal 100%;

- (b) an acid scavenger in an amount effective to neutralize phosphoric acid and phosphoric acid partial esters formed in situ by hydrolysis of any of the phosphate esters of said base stock;

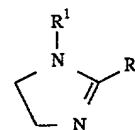
- (c) an anti-erosion additive in an amount effective to inhibit flow-induced electrochemical or zeta corrosion of the flow-metering edges of hydraulic servo valves in hydraulic systems;

- (d) a viscosity index improver in an amount effective to cause the fluid composition to exhibit a viscosity of at least about 3.0 centistokes at about 210° F., at least about 9.0 centistokes at about 100° F., and less than about 4200 centistokes at -65° F.; and

- (e) an antioxidant in an amount effective to inhibit oxidation of fluid composition components in the presence of oxidizing agents.

51. A fluid composition as set forth in claim 50 further comprising benzotriazole or a benzotriazole derivative in a proportion of between about 0.005% and about 0.09% by weight as a copper corrosion inhibitor.

52. A fluid composition as set forth in claim 50 or 51 further comprising a 4,5-dihydroimidazole compound corresponding to the formula



wherein R¹ is selected from the group consisting of hydrogen, alkyl, alkenyl, hydroxyalkyl, hydroxyalkenyl, alkoxyalkyl and alkoxyalkenyl, and R² is selected from the group consisting of alkyl, alkenyl and aliphatic carboxylate.

53. A fluid composition as set forth in claim 52 wherein the 4,5-dihydroimidazole compound is present in a proportion of between about 0.01% and about 0.1% by weight of

the fluid composition.

54. A fluid composition as set forth in claim 52 wherein the 4,5-dihydroimidazole is selected from the group consisting of 2-(8-heptadecenyl)-4,5-dihydro-1H-imidazole-1-ethanol and the condensation product of a C₁₄ to C₁₅ fatty acid and 4,5-dihydro-1H-imidazole.

55. A fluid composition as set forth in claim 54 wherein the 4,5-dihydroimidazole compound is the condensation product of a C₁₆ to C₁₈ fatty acid and 4,5-dihydro-1H-imidazole.

56. A fluid composition suitable for use as an aircraft hydraulic fluid, comprising:

- (a) a fire resistant phosphate ester base stock, said base stock comprising between about 10% and about 100% by weight of a trialkyl phosphate in which the alkyl substituents are substantially isoalkyl C₄ or C₅ and are bonded to the phosphate moiety via a primary carbon atom, between about 0% and about 70% by weight of a dialkyl aryl phosphate in which the alkyl substituents are as previously defined, and between about 0% and about 25% by weight of an alkyl diaryl phosphate in which the alkyl substituent is as previously defined, with the proviso that the sum of the proportionate amount of each base stock component must equal 100%;
- (b) an acid scavenger in an amount effective to neutralize phosphoric acid and phosphoric acid partial esters formed in situ by hydrolysis of any of the phosphate esters of said base stock;
- (c) an anti-erosion additive in an amount effective to inhibit flow-induced electrochemical or zeta corrosion of the flow-metering edges of hydraulic servo valves in hydraulic systems;
- (d) a viscosity index improver in an amount effective to cause the fluid composition to exhibit a viscosity of at least about 3.0 centistokes at about 210° F., at least about 9.0 centistokes at about 100° F., and less than about 4200 centistokes at -65° F.; and
- (e) an antioxidant in an amount effective to inhibit oxidation of fluid composition components in the presence of oxidizing agents.

57. A fluid composition as set forth in claim 56 wherein the phosphate esters containing an aryl substituent do not constitute more than about 25% by weight of the base stock.

58. A fluid composition as set forth in claim 56 wherein the viscosity index improver is present in a proportion of between about 3% and about 10% by weight of the fluid composition.

59. A fluid composition as set forth in claim 56 wherein the viscosity index improver is a methacrylate ester polymer, the repeating units of which substantially comprise butyl and hexyl methacrylate, at least 95% by weight of the polymer having a molecular weight of between about 50,000 and about 1,500,000.

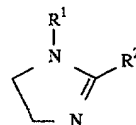
60. A fluid composition as set forth in claim 56 wherein the antioxidant comprises a 2,4,6-trialkylphenol in a proportion of between about 0.1% and about 1.0% by weight of the composition, a di(alkylphenyl)amine in a proportion of between about 0.3% and about 1.0% by weight of the fluid composition, and a hindered polyphenol selected from the group consisting of bis(3,5-dialkyl-4-hydroxyaryl)methane and 1,3,5-trialkyl-2,4,6-tris(3,5-di-tert-butyl-4-hydroxyaryl)benzene, and mixtures thereof, in a proportion of between about 0.3% and about 1.0% by weight of the fluid composition.

61. A fluid composition as set forth in claim 60 wherein

the 2,4,6-trialkylphenol is 2,6-di-tert-butyl-p-cresol and the hindered polyphenol is selected from the group consisting of bis(3,5-di-tert-butyl-4-hydroxyphenyl)methane, 1,3,5-trimethyl-2,4,6-tris(3,5-di-tert-butyl-4-hydroxyphenyl)benzene, and mixtures thereof.

62. A fluid composition as set forth in claim 56 further comprising benzotriazole or a benzotriazole derivative in a proportion of between about 0.005% and about 0.09% by weight as a copper corrosion inhibitor.

63. A fluid composition as set forth in claim 56 or 62 further comprising a 4,5-dihydroimidazole compound corresponding to the formula



where R¹ is selected from the group consisting of hydrogen, alkyl, alkenyl, hydroxyalkyl, hydroxyalkenyl, alkoxyalkyl and alkoxyalkenyl, and R² is selected from the group consisting of alkyl, alkenyl and aliphatic carboxylate.

64. A fluid composition as set forth in claim 63 wherein the 4,5-dihydroimidazole compound is present in a proportion of between about 0.01% and about 0.1% by weight of the fluid composition.

65. A fluid composition as set forth in claim 63 wherein the 4,5-dihydroimidazole is selected from the group consisting of 2-(8-heptadecenyl)-4,5-dihydro-1H-imidazole-1-ethanol and the condensation product of a C₁₄ to C₁₈ fatty acid and 4,5-dihydro-1H-imidazole.

66. A fluid composition as set forth in claim 65 wherein the 4,5-dihydroimidazole compound is the condensation product of a C₆ to C₈ fatty acid and 4,5-dihydro-1H-imidazole.

67. A fluid composition suitable for use as an aircraft hydraulic fluid, comprising:

- (a) a fire resistant phosphate ester base stock, the base stock comprising between about 10% and about 100% by weight of a trialkyl phosphate in which the alkyl substituents are substantially isoalkyl C₄ or C₅ and are bonded to the phosphate moiety via a primary carbon atom, between about 0% and about 35% by weight of a dialkyl aryl phosphate in which the alkyl substituents are as previously defined, and between about 0% and about 20% by weight of a triaryl phosphate, with the proviso that the sum of the proportionate amount of each base stock component must equal 100%;
- (b) an acid scavenger in an amount effective to neutralize phosphoric acid and phosphoric acid partial esters formed in situ by hydrolysis of any of the phosphate esters of said base stock;
- (c) an anti-erosion additive in an amount effective to inhibit flow-induced electrochemical or zeta corrosion of the flow-metering edges of hydraulic servo valves in hydraulic systems;
- (d) a viscosity index improver in an amount effective to cause the fluid composition to exhibit a viscosity of at least about 3.0 centistokes at about 210° F., at least about 9.0 centistokes at about 100° F., and less than about 4200 centistokes at -65° F.; and
- (e) an antioxidant in an amount effective to inhibit oxidation of fluid composition components in the presence of oxidizing agents.

68. A fluid composition as set forth in claim 67 wherein

the phosphate esters containing an aryl substituent do not constitute more than about 25% by weight of the base stock.

69. A fluid composition as set forth in claim 67 wherein the viscosity index improver is present in a proportion of between about 3% and about 10% by weight of the fluid composition.

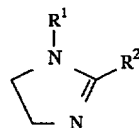
70. A fluid composition as set forth in claim 67 wherein the viscosity index improver is a methacrylate ester polymer, the repeating units of which substantially comprise butyl and hexyl methacrylate, at least 95% by weight of the polymer having a molecular weight of between about 50,000 and about 1,500,000.

71. A fluid composition as set forth in claim 67 wherein the antioxidant comprises a 2,4,6-trialkylphenol in a proportion of between about 0.1% and about 1.0% by weight of the composition, a di(alkylphenyl)amine in a proportion of between about 0.3% and about 1.0% by weight of the fluid composition, and a hindered polyphenol selected from the group consisting of bis(3,5-dialkyl-4-hydroxyaryl)methane and 1,3,5-trialkyl-2,4,6-tris(3,5-di-tert-butyl-4-hydroxyaryl)benzene, and mixtures thereof, in a proportion of between about 0.3% and about 1.0% by weight of the fluid composition.

72. A fluid composition as set forth in claim 71 wherein the 2,4,6-trialkylphenol is 2,6-di-tert-butyl-p-cresol and the hindered polyphenol is selected from the group consisting of bis(3,5-di-tert-butyl-4-hydroxyphenyl)methane, 1,3,5-trimethyl-2,4,6-tris(3,5-di-tert-butyl-4-hydroxyphenyl)benzene, and mixtures thereof.

73. A fluid composition as set forth in claim 67 further comprising benzotriazole or a benzotriazole derivative in a proportion of between about 0.005% and about 0.09% by weight as a copper corrosion inhibitor.

74. A fluid composition as set forth in claim 67 or 73 further comprising a 4,5-dihydroimidazole compound corresponding to the formula



where R¹ is selected from the group consisting of hydrogen, alkyl, alkenyl, hydroxyalkyl, hydroxyalkenyl, alkoxyalkyl and alkoxyalkenyl, and R² is selected from the group consisting of alkyl, alkenyl and aliphatic carboxylate.

75. A fluid composition as set forth in claim 74 wherein the 4,5-dihydroimidazole compound is present in a proportion of between about 0.01% and about 0.1% by weight of the fluid composition.

76. A fluid composition as set forth in claim 74 wherein the 4,5-dihydroimidazole is selected from the group consisting of 2-(8-heptadecenyl)-4,5-dihydro-1H-imidazole-1-ethanol and the condensation product of a C₁₄ to C₁₈ fatty acid and 4,5-dihydro-1H-imidazole.

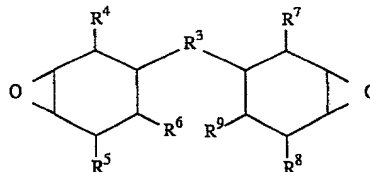
77. A fluid composition as set forth in claim 16 wherein the 4,5-dihydroimidazole compound is the condensation product of a C₁₆ to C₁₈ fatty acid and 4,5-dihydro-1H-imidazole.

78. A fluid composition suitable for use as an aircraft hydraulic fluid, comprising:

- (a) a fire resistant phosphate ester base stock comprising between about 35% and about 99% by weight of a trialkyl phosphate wherein the alkyl substituents are substantially isoalkyl C₄ or C₅ and are bonded to the phosphate moiety via a primary carbon atom, between

about 0% and about 35% by weight of a dialkyl aryl phosphate wherein the alkyl substituents are as previously defined, and between about 0% and about 20% by weight of a triaryl phosphate, with the proviso that the sum of the proportionate amount of each base stock component must equal 100%;

- (b) a viscosity index improver in a proportion of between about 3% and about 10% by weight of the fluid composition, the viscosity index improver comprising a methacrylate ester polymer, the repeating units of which substantially comprise butyl and hexyl methacrylate, at least 95% by weight of the polymer having a molecular weight of between about 50,000 and about 1,500,000;
- (c) an anti-erosion agent in a proportion of between about 0.02% and about 0.08% by weight of the fluid composition, the anti-erosion agent comprising an alkali metal salt of a perfluoroalkyl sulfonic acid, the alkyl substituent of which is selected from the group consisting of hexyl, heptyl, octyl, nonyl, decyl, and mixtures thereof;
- (d) an acid scavenger in a proportion of between about 1.5% and about 10% by weight of the fluid composition, the acid scavenger selected from the group consisting of a derivative of a 3,4-epoxy cyclohexane carboxylate and a diepoxide compound corresponding to the formula



wherein R³ is an organic group containing 1 to 10 carbon atoms, from 0 to 6 oxygen atoms and from 0 to 6 nitrogen atoms, and R⁴ through R⁹ are independently selected from among hydrogen and aliphatic groups containing 1 to 5 carbon atoms, and mixtures of the 3,4-epoxycyclohexane carboxylate and the diepoxide compound;

- (e) 2,4,6-trialkylphenol in a proportion of between about 0.1% and about 1.0% by weight of the fluid composition;
- (f) a di(alkylphenyl)amine in a proportion of between about 0.3% and about 1.0% by weight of the fluid composition; and
- (g) a hindered polyphenol selected from the group consisting of bis(3,5-dialkyl-4-hydroxyaryl)methane, 1,3,5-trimethyl-2,4,6-tris(3,5-di-tert-butyl-4-hydroxyaryl)benzene and mixtures thereof in a proportion of between about 0.3% and about 1.0% by weight of the fluid composition.

79. A fluid composition as set forth in claim 78 wherein the base stock comprises between about 80% and about 99% by weight of the trialkyl phosphate and between about 1.0% and about 20% by weight of the triaryl phosphate wherein the aryl substituents are alkyl-substituted phenyl.

80. A fluid composition as set forth in claim 79 wherein the alkyl substituent of the alkyl-substituted phenyl is C₂ to C₉.

81. A fluid composition as set forth in claim 80 wherein the alkyl substituent of the alkyl-substituted phenyl is C₃ to C₄.

82. A fluid composition as set forth in claim 81 wherein

52

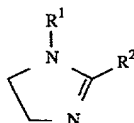
where R¹ is selected from the group consisting of hydrogen, alkyl, alkenyl, hydroxyalkyl, hydroxyalkenyl, alkoxyalkyl and alkoxyalkenyl, and R² is selected from the group consisting of alkyl, alkenyl and aliphatic carboxylate.

87. A fluid composition as set forth in claim **86** wherein the 4,5-dihydroimidazole compound is present in a proportion of between about 0.01% and about 0.1% by weight of the fluid composition.

88. A fluid composition as set forth in claim **86** wherein the 4,5-dihydroimidazole is selected from the group consisting of 2-(8-heptadecenyl)-4,5-dihydro-1H-imidazole-1-ethanol and the condensation product of a C₁₄ to C₁₈ fatty acid and 4,5-dihydro-1H-imidazole.

89. A fluid composition as set forth in claim **88** wherein the 4,5-dihydroimidazole compound is the condensation product of a C₁₆ to C₁₈ fatty acid and 4,5-dihydro-1H-imidazole.

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